STRUCTURE OF THE SPECTRUM OF DOUBLY IONISED BROMINE

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Plate VI and Plate VII (A and B)

ABSTRACT. The earlier analysis of the spectrum of Br III is revised and extended. A large number of levels belonging to the various configurations are newly identified, leading to the classification of more than 200 lines, which bring the total of classified lines to about 230. The doublets are correctly identified and are confirmed by the intercombinations with the quartets. The third ionisation potential of bromine given in the earlier analysis is verified to be correct.

INTRODUCTION

The first important investigation on the spectrum of doubly ionised bromine is by Bloch and Bloch (1927) who have given a fairly extensive list of the lines of Br III in the region 6600-2200A using a source of electodeless discharge. Lacroute (1935) has extended the list with measurements in the vacuum ultra-violet region on a 1-metre normal incidence vacuum grating spectrograph using a source of electrodeless discharge similar to the one employed by Bloch and Bloch.

Rao and Krishna Murty (1937) are the first to make a beginning towards the correct analysis of the structure of the spectrum. They have rejected the analysis given by Deb (1930) and successfully identified the deepest and fundamental quarters of the $4p^3$, 5s, 5p and 6s configurations and calculated the ionisation potential from the two members of the *ns* ^4P series. They have given a tentative list of some levels belonging to 4d and 5d configurations basing the assignments on the magnitude of the levels but without specific designation as that would be uncertain in the absence of other evidence.

They have also given a tentative identification of some of the doublets of $4p^3$, 5s and 5p configurations, independent of the quarters. The identifications are based, as stated by them, mainly on the detection of several pairs in the region below 1000A having the characteristic interval 1664 cm^{-1} which is of the order of the predicted interval $4p^3\ ^2P_{\frac{1}{2}}^0-4p^3\ ^2P_{1\frac{1}{2}}^0$. From these pairs the doublet groups $4p^3\ ^2D^0$, $^2P^0-5s\ ^2P$, $5s'\ ^2D$ are built up although some of the combinations are absent. By extrapolation into the shorter wavelength region some of the 5p doublet levels have been located. It is also remarked that some of the levels assigned to the 4d and 5d configurations might in fact be doublet levels. Pending further investigation the publication of intercombinations was withheld. In a later communication Rao (1944) has reported the identification of a few intercombinations and has given the interval $4p^3\,{}^4S_{1\frac{1}{2}}{}^0 - 4p^3\,{}^2D_{1\frac{1}{2}}{}^0$ as 15042 cm^{-1}.

Moore (1952) has collected in the book "Atomic Energy Levels, Vol. II" all the energy levels given in the paper of Rao and Krishna Murty (1937) arranging them in the ascending order of magnitude with $4p^3\,{}^4S_{1\frac{1}{2}}$ as zero. She has added the correction 15042 cm^{-1} (Rao, 1944) to all the doublets starting with $4p^3\ {}^2D_{1\frac{1}{2}}{}^0$ as zero.

Still there remain quite a large number of lines unclassified, and the analysis is very far from complete and needs confirmation. In pursuance of the analysis obtained of the spectrum of Br II (Bhupala Rao, 1958), a revision of the analysis of the spectrum of Br III has been undertaken. The extensive experimental work on the spectrum done in connection with Br II has served for the purpose of this analysis also. The investigation has shown that while the quartet levels are confirmed, the doublets and intercombinations given by Rao and Krishna Murty (1937) and Rao (1944 and unpublished work) need revision except the level $4p^3\ {}^2D_{2\frac{1}{2}}{}^0$. A large number of new levels are also identified and intercombinations are definitely established leading to the classification of more than 200 additional lines bringing the total of classified lines to about 230.

EXPERIMENTAL

The sources of radiation and other details about excitation and recording of the spectrum are given in the paper on Br II (Bhupala Rao, 1958).

As already mentioned in the paper on Br II (Bhupala Rao, 1958) in addition to the data obtained from the experimental work at the Andhra University by the author, a large number of photographs were also kindly made available to the author by Prof. K. R. Rao and were of very great help. These pictures extending from 1085 to 480A were taken at Upsala with a Grazing Incidence Spectrograph long ago and well preserved. The dispersion was about 3.2A/mm near 950A. The sources consisted of a vacuum spark between electrodes tipped with Rb Br and Cs Br. Full details regarding the pictures are given by Rao and Badami (1931) in the paper on Se IV.

The lines of Br III are distinguished from the lines of Br II in the infra-red, visible and near ultraviolet regions by the criterion that a complete or partial suppression of the second and higher spark lines occurs when a suitable inductance is placed in the condensed discharge circuit while the intensity of the first spark lines either remains unaltered or increases. Several of the Br III lines are hazy and have large intense wings on the long wavelength side in the condensed discharge, which make their measurement difficult. The lines of Br. IV are comparatively sharp and are completely suppressed when the inductance is included in the circuit. Since some of the Br III lines also are completely suppressed on including the inductance the behaviour of the lines in rectified discharge also is taken into consideration for distinguishing the lines of Br III from the lines of Br IV. In the rectified discharge, under suitable conditions, some of the Br IV lines appear with more intensity than in the condensed discharge. Though these criteria give fairly good results they are not entirely critical and cannot be depended upon to give absolutely correct results, because for a given ion lines from higher energy states behave in much the same way as those from next ion. In the vacuum ultraviolet region where lines from lower energy states occur, several lines of Br III appear in the inductance picture also with comparable intensity and it is difficult to distinguish them from the Br II lines. In this region a few higher stage spark lines also seem to be present in the inductance picture. An intensive examination of the entire spectrum and a line by line scrutiny has become necessary for the ultimate assignment.

All the lines of Br III classified in this investigation are given in Table II with their intensities in condensed discharge, wavelengths, wavenumbers and classifications. As in the case of Br II, in this paper also the wavelengths below 2000A are values in vacuum.

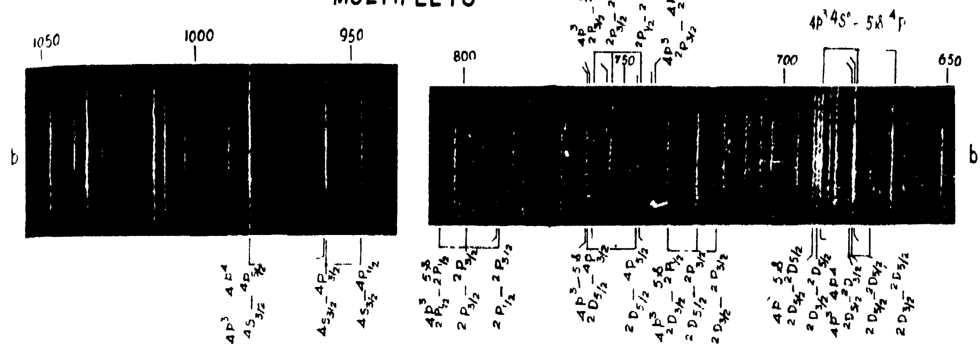
ANALYSIS

Br III is isoelectronic with As I, Se II, and Kr IV which have been respectively investigated by Meggers, Shenstone and Moore (1950), by Krishna Murty and Rao (1935) and Martin (1935) and by Boyce (1935) and Rao and Krishna Murty (1939). The structures of As I and Se II are almost completely known but the analysis of Kr IV is sketchy and far from complete.

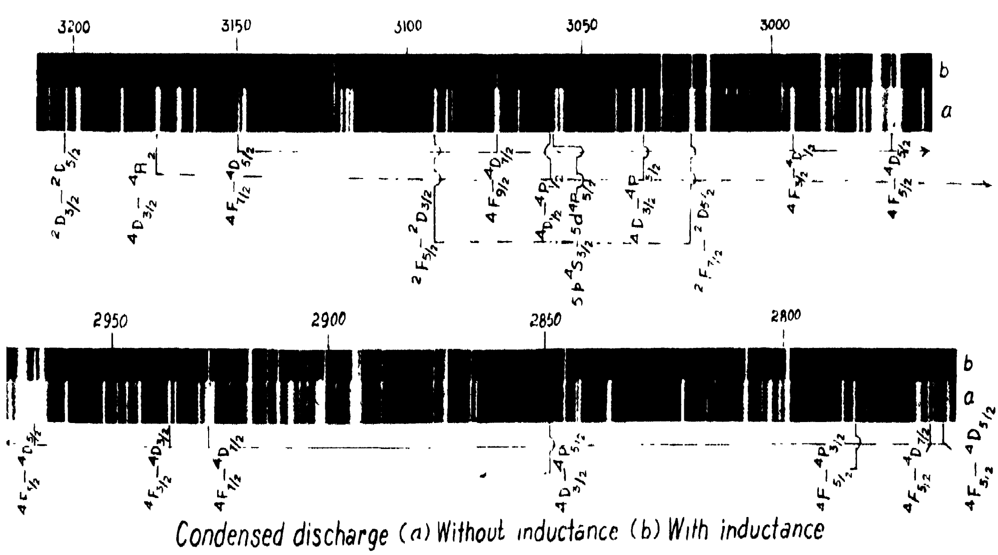
The predicted terms of Br III are given in Table I. Terms identified completely or partially are underlined. Those identified in the earlier investigations are marked with an asterisk also. All the newly identified levels are already given in the preliminary note (Bhupala Rao, 1956) in the ascending order of magnitude based on $4p^3\ {}^4S^0_{1\frac{1}{2}}$ as zero. Following the notation adopted by Moore (1952) levels arising from the ^1D and ^1S states of the Br IV ion are distinguished by affixing a single prime and a double prime respectively to the running electron.

The analysis presented in this paper shows that there is a considerable overlapping of the terms of the same configuration and also of the terms of different configurations. The term intervals are as large as and sometimes even larger than the separations between the neighbouring terms showing very great departure from L-S coupling. The ratios of the intervals of the individual terms also show large deviations from the values predicted on the basis of L-S coupling. Unlike in Br II the combinations between even and odd levels are not profuse and it makes the analysis very difficult. Particularly, the combinations between the doublets of even and odd configurations are only a few. Some of the doublets give more combinations with the quartets than with the doublets, the intercombinations being thus relatively more intense.

$4p^3\,{}^4S^\circ - 4p^4\,{}^4P$ and $4p^3\,{}^2D^\circ, {}^2P^\circ - 5s\,{}^2P, 5s'\,{}^2D, 4p^4\,{}^2D$ MULTIPLETS



$4d\,{}^4F - 5p\,{}^4D^\circ$, $4d\,{}^4D - 5p\,{}^4P^\circ$ and $4d\,{}^2F - 5p\,{}^2D^\circ$ MULTIPLETS



Condensed discharge (a) Without inductance (b) With inductance

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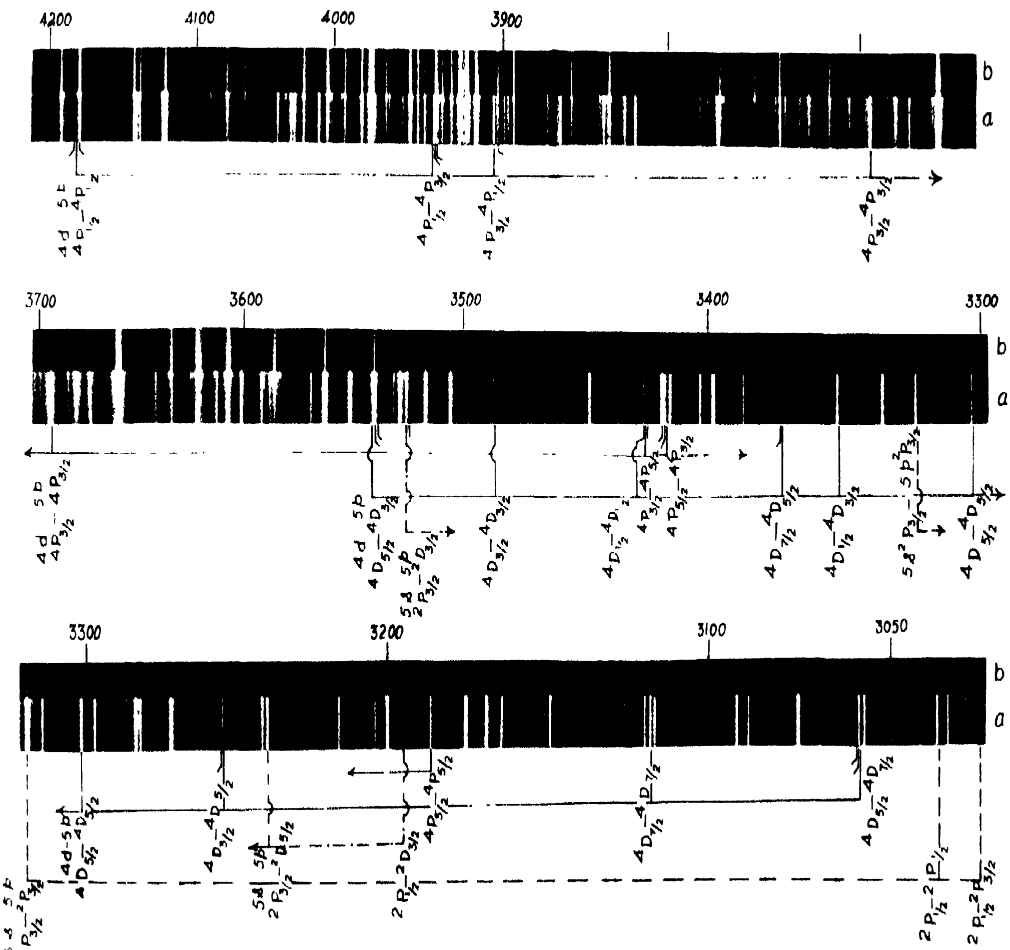
PLATE VII A

$4d\,{}^4D - 5p\,{}^4D^\circ$; $4d\,{}^4P - 5p\,{}^4P^\circ$, $5s\,{}^2P - 5p\,{}^2P^\circ$ and $5s\,{}^2P - 5p\,{}^2D^\circ$ MULTIPLETS



Condensed discharge (a) Without inductance (b) With inductance

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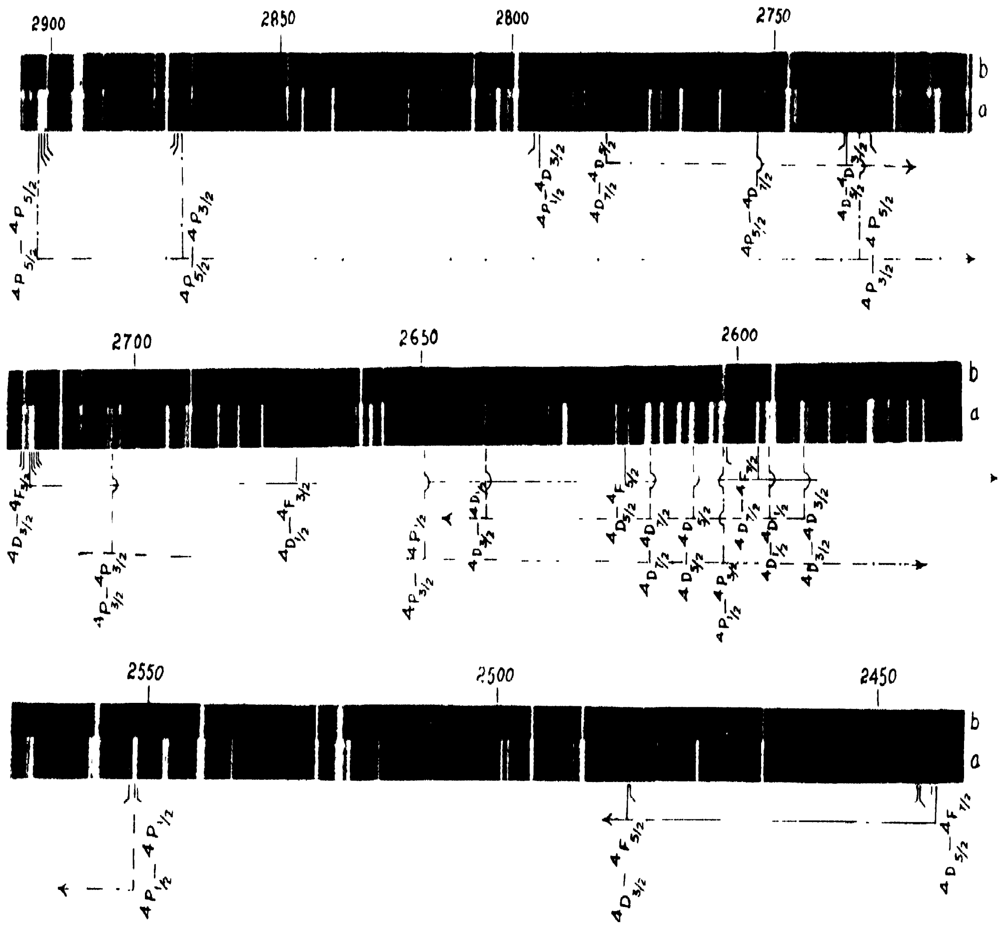
PLATE VI B

5p-5d MULTIPLETS



Condensed discharge (a) Without inductance (b) With inductance

A careful examination of the plates has confirmed the previous identification of the quartets of $4p^3$, 5s, 5p and 6s configurations. The intensity and behaviour of the lines are in conformity with the classifications. Examination of the doublets previously suggested is then taken up. A series of trials have been made to enlarge the scheme of classification assuming Rao and Krishna Murthy's identification of doublets as correct. All the attempts have proved to be unsuccessful. It is presumed that it is the failure to make correct assignment of the doublets and the intercombinations with the quartets that might have led to difficulty in extending the analysis further by Rao and Krishna Murty themselves. Therefore an independent and fresh approach to the identification of doublets is made with the aid of the irregular doublet law. The application of the irregular doublet law in the manner done by Bowen and Millikan and used by Rao (1927) in the analysis of the Sn III spectrum for transitions where the principal quantum number changes, is employed. By comparing with the values in As I and Se II using the irregular doublet law, the positions for the $4p^3\ {}^2D_{2\frac{1}{2}}{}^0-5s\ {}^2P_{1\frac{1}{2}}$, $4p^3\ {}^2D_{1\frac{1}{2}}{}^0-5s\ {}^2P_{\frac{1}{2}}$, $4p^3\ {}^2P_{1\frac{1}{2}}{}^0-5s\ {}^2P_{1\frac{1}{2}}$ and $4p^3\ {}^2P_{\frac{1}{2}}{}^0-5s\ {}^2P_{\frac{1}{2}}$ combinations in Br III are calculated to be 136387, 133843, 123902 and 121705 cm^{-1} respectively. With the help of these calculated values and the predicted intervals for the $4p^3\ {}^2D^0$, ${}^2P^0$ and $5s\ {}^2p$ terms the identifications of the doublets are made. With the assignments of Rao and Krishna Murty no intercombinations between the $5s\ {}^2P$ levels and the 5p quarters could be observed. With the present choice the intercombination lines are observed in the calculated positions. Also, the intensities of the lines confirm the present assignments. From these it has been possible to establish the $4p^3\ {}^2D^0$, ${}^2P^0$, $4p^4\ {}^2D$, $5s\ {}^2P$ and $5s'\ {}^2D$ terms. The identification of the $5s'\ {}^2D$ and $4p^4\ {}^2D$ terms proved to be more difficult because of the intensity anomalies in their combinations and their proximity to each other. Starting with the doublets of the 5s configuration and by a comparison of the position of $np^2(n+1)s\ {}^2P_{1\frac{1}{2}}-np^2(n+1)p\ {}^2P_{1\frac{1}{2}}{}^0$ combinations in the spectra isoelectonic with F III, Cl III and Br III the $5p\ {}^2P_{1\frac{1}{2}}{}^0$, ${}^2D_{2\frac{1}{2}}{}^0$ levels are located at 105581.0 and 107331.0 respectively. Proceeding from these with the help of the estimated intervals of the 5p doublets the $5p\ {}^2D^0$, ${}^2P^0$ and ${}^2S^0$ terms are identified completely. This also proved somewhat difficult because of the poor development of the multiplets. The 5p doublets combine only with a few of the terms of the even configurations. Attempts to identify the 5p′ doublet levels with the help of the $5s'\ {}^2D$ interval have been unsuccessful. The transitions between the doublets of $4p^3$ and 5s, $4p^4$ configurations are shown in Plate VI and the combinations between the doublets of 5s and 5p configurations in Plate VIIA.

From a study of the position of the $4p^3\ {}^4S^0-4p^4\ {}^4P$ multiplet and the intervals of the $4p^4\ {}^4P$ term in spectra isoelectonic with F III, Cl III and Br III this multiplet in Br III is estimated to be in the region 100,000—110,000 cm^{-1} with ${}^4P_{\frac{1}{2}}-{}^4P_{1\frac{1}{2}}$ and ${}^4P_{1\frac{1}{2}}-{}^4P_{2\frac{1}{2}}$ intervals of the order of −1260 and −2650 respectively. After a close scrutiny of the plates for three lines in that region with the estimated intervals, the lines 105380, 104129 and 101532 cm^{-1} are classified as the combinations respectively of $4p^4\ ^4P_{\frac{1}{2},1\frac{1}{2},2\frac{1}{2}}$ levels with $4p^3\ ^4S_{1\frac{1}{2}}^0$. Their intervals -1251 and -2597 agree well with the predicted values. These classifications are confirmed by the large number of combinations between the resulting levels and the 5p quartet terms. The $4p^3\ ^4S^0-4p^4\ ^4P$ multiplet is shown in Plate VI.

Rao and Krishna Murty (1937) have assigned nine levels to the 4d configuration on consideration of their magnitude. But they have stated that some of them might actually be doublet levels. Attempts to identify the 4d levels starting with the 5p $^4D^0$ and $^4P^0$ intervals have resulted in the identification of the $4p^4\ ^2P$ term, all the 4d quartets, the 4d ^2F term, the 4d $^2D_{1\frac{1}{2}}$, $^2P_{1\frac{1}{2}}$ levels and three other levels designated 1, 2 and 3. Of the nine given by Rao and Krishna Murty, only the five levels 2, 3, 5, 6 and 9 are found to be real, and of these the level 2 is identified as $4p^4\ ^2P_{1\frac{1}{2}}$. The $4p^4\ ^2P$ term does not combine with any of the $4p^3$ levels.

The 4d ^4F, ^4D terms combine well with the 5p $^4D^0$ term, but seldom with 5p $^4P^0$ term. In the case of the 4d ^4P term, the 4d $^4P-5p\ ^4P^0$ multiplet and 4d $^4P_{1\frac{1}{2}}-5p\ ^4D_{\frac{1}{2}}^0$, 4d $^4P_{\frac{1}{2}}-5p\ ^4S^0_{1\frac{1}{2}}$ and 4d $^4P_{1\frac{1}{2}}-5p\ ^2P_{1\frac{1}{2}}^0$ combinations alone could be located. Except for two lines the 4d levels do not give any combinations with the 5p $^2P^0$ and $^2S^0$ terms. Even with the 5p $^2D^0$ term the combinations are only a few. The 4d ^4P term is inverted while the other terms are regular. But none of these is in conformity with L–S coupling. The 4d $^4F-5p\ ^4D^0$, 4d $^4D-5p\ ^4D^0$ and 4d $^4P-5p\ ^4P^0$ multiplets are shown in Plates VI and VIIA.

The 5d quartet terms also are arrived at with the help of the intervals of the 5p quartets. Only two, 11 and 13, of the seven levels 10 to 16 assigned by Rao and Krishna Murty to the 5d configuration, could be confirmed. The 5d terms exhibit combining characteristics similar to the 4d terms and their combinations with the odd levels are not profuse. Here too the term intervals are not regular and show large deviations from L-S coupling. The 5d ^4P term also is inverted. This inversion of the nd ^4P term is a feature present in the spectra of F III and Cl III also.

The diagonal lines of the 5p $^4D^0-5d\ ^4F$ multiplet are diminishing in intensity with increasing J values. From this trend in the variation of intensity the combination 5p $^4D_{3\frac{1}{2}}^0-5d\ ^4F_{4\frac{1}{2}}$ is expected to be very weak, and since this is the only combination the 5d $^4F_{4\frac{1}{2}}$ level gives with the 5p levels, it is not found possible to fix this line. Consequently the 5d $^4F_{4\frac{1}{2}}$ level is not identified. The 5p $^4D^0-5d\ ^4F$, 5p $^4D^0-5d\ ^4D$ and 5p $^4P^0-5d\ ^4P$ multiplets are marked on Plate VIIB.

The doublets of the 5d and 6s configurations are all expected to be of the same order of magnitude and it is not possible to distinguish between the levels of the two configurations. So, all these levels are designated arbitrarily by numerals 4 to 22.

TABLE I

Terms of Br III

Configuration	Terms		
$4s^2\ 4p^3$	$^4S^0$*	$^2D^0$	$^2P^0$
$4s\ 4p^4$	^4P	^2P	^2D	^2S
Basic terms of Br IV $4s^2\ 4p^2$	^3P	^1D	^1S
$4s^2\ 4p^2\ 5s$	^4P* ^2P	^2D	^2S
$4s^2\ 4p^2\ 4d$	^4F ^4D ^4P ^2F ^2D ^2P	^2G ^2F ^2D ^2P ^2S	^2D
$4s^2\ 4p^2\ 5p$	$^4D^0$* $^4P^0$* $^4S^0$* $^2D^0$ $^2P^0$ $^2S^0$	$^2F^0$ $^2D^0$ $^2P^0$	$^2P^0$
$4s^2\ 4p^2\ 6s$	^4P* ^2P	^2D	^2S
$4s^2\ 4p^2\ 5d$	^4F ^4D ^4P ^2F ^2D ^2P	^2G ^2F ^2D ^2P ^2S	^2D
$4s^2\ 4p^2\ 6p$	$^4D^0$ $^4P^0$ $^4S^0$ $^2D^0$ $^2P^0$ $^2S^0$	$^2F^0$ $^2D^0$ $^2P^0$	$^2P^0$

*......Identified in previous investigations.

TABLE II

Newly classified lines of Br III

Intensity	λ(air)	ν(vac)	Classification	Remarks
0bh	7696.1	12990	5d $^4F_{3\frac{1}{2}}-23^0$	
2	7673.1	13029	$4p^4$ $^2D_{1\frac{1}{2}}-5p$ $^4P^0_{\frac{1}{2}}$	
2	7192.8	13899	6s $^4P_{2\frac{1}{2}}-23^0$	
00b	6899.8	14489	$4p^4$ $^2D_{1\frac{1}{2}}-5p$ $^4P^0_{1\frac{1}{2}}$	Br II line
1	6459.21	15477.5	5s′ $^2D_{1\frac{1}{2}}-5p$ $^4P^0_{\frac{1}{2}}$	
1hb	5947.90	16808.0	6s $^4P_{1\frac{1}{2}}-23^0$	
1	5764.09	17344.0	5d $^4P_{1\frac{1}{2}}-24^0$	
1	5693.40	17559.3	$11-24^0$	
2	5446.80	18354.3	$4p^4$ $^2D_{2\frac{1}{2}}-5p$ $^2D^0_{1\frac{1}{2}}$	
0	5440.38	18376.0	$4p^4$ $^2D_{1\frac{1}{2}}-5p$ $^4S^0_{1\frac{1}{2}}$	Br II line

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
00	5245.25	19059.6	5s′ $^2D_{1\frac{1}{2}}$ − 5p $^4P^o_{2\frac{1}{2}}$	
3	5175.87	19315.1	4d $^2P_{1\frac{1}{2}}$ − 5p $^4D^o_{\frac{1}{2}}$	
1	5146.32	19426.0	6s $^4P_{1\frac{1}{2}}$ − 24°	
0	4896.67	20416.4	5p $^2P^o_{\frac{1}{2}}$ − 6	
1	4803.14	20813.9	5s′ $^2D_{1\frac{1}{2}}$ − 5p $^2S^o_{\frac{1}{2}}$	
00	4661.58	21446.0	5p $^4S^o_{1\frac{1}{2}}$ − 5	
3	4556.49	21940.6	5s′ $^2D_{2\frac{1}{2}}$ − 5p $^2D^o_{1\frac{1}{2}}$	
4	4519.74	22119.0	4d $^4P_{1\frac{1}{2}}$ − 5p $^4D^o$	
3	4393.51	22754.5	5s′ $^2D_{1\frac{1}{2}}$ − 5p $^2P^o_{1\frac{1}{2}}$	
3	4383.91	22804.3	4d $^2P_{1\frac{1}{2}}$ − 5p $^4P^o_{\frac{1}{2}}$	
1	4319.49	23144.4	5p $^4S^o_{1\frac{1}{2}}$ − 7	
0	4316.15	23162.3	4d $^2D_{1\frac{1}{2}}$ − 5p $^4P^o_{\frac{1}{2}}$	
1hb	4219.15	23694.8	3 − 5p $^4P^o_{\frac{1}{2}}$	
1h	4190.82	23855.0	2 − 5p $^4D^o_{\frac{1}{2}}$	
1	4181.73	23906.8	4d $^4P_{\frac{1}{2}}$ − 5p $^4P^o_{\frac{1}{2}}$	
00vb	4166.58	23993.8	5p $^4P^o_{2\frac{1}{2}}$ − 6	
3	4120.34	24263.0	4d $^2P_{1\frac{1}{2}}$ − 5p $^4P^o_{1\frac{1}{2}}$	
2H	4116.70	24284.5	5s $^2P_{1\frac{1}{2}}$ − 5p $^4P^o_{1\frac{1}{2}}$	
			4d $^2F_{3\frac{1}{2}}$ − 5p $^4D^o_{2\frac{1}{2}}$	
3hb	4086.63	24463.2	5s′ $^2D_{2\frac{1}{2}}$ − 5p $^2D^o_{2\frac{1}{2}}$	Br II line
00b	4078.36	24512.8	2 − 5p $^4D^o_{1\frac{1}{2}}$	
0Hb	4059.99	24623.7	4d $^2D_{1\frac{1}{2}}$ − 5p $^4P^o_{1\frac{1}{2}}$	
0	3977.83	25131.3	5p $^4P^o_{1\frac{1}{2}}$ − 4	
0b	3974.34	25154.3	3 − 5p $^4P^o_{1\frac{1}{2}}$	
0	3963.18	25225.2	5p $^4S^o_{1\frac{1}{2}}$ − 8	
0	3946.00	25335.0	5p $^4P^o_{1\frac{1}{2}}$ − 5	
00	3941.13	25366.3	4d $^4P_{\frac{1}{2}}$ − 5p $^4P^o_{1\frac{1}{2}}$	
4	3903.95	25607.9	4d $^4P_{1\frac{1}{2}}$ − 5p $^4P^o_{\frac{1}{2}}$	
0b	3880.25	25764.3	5s $^2P_{\frac{1}{2}}$ − 5p $^4P^o_{\frac{1}{2}}$	
2hb	3838.34	26045.6	4d $^2F_{2\frac{1}{2}}$ − 5p $^4D^o_{2\frac{1}{2}}$	
2	3788.67	26387.0	4d $^2P_{1\frac{1}{2}}$ − 5p $^4P^o_{2\frac{1}{2}}$	

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
2	3785.77	26407.2	5s $^2P_{1\frac{1}{2}}$ – 5p $^4P^o_{2\frac{1}{2}}$	
0h	3760.72	26583.1	2 – 5p $^4D^o_{2\frac{1}{2}}$	
00	3744.57	26697.1	4d $^2F_{3\frac{1}{2}}$ – 5p $^4D^o_{3\frac{1}{2}}$	Br II line
1	3731.07	26794.4	5p $^4P^o_{\frac{1}{2}}$ – 5	
2h	3724.75	26839.8	5p $^4D^o_{3\frac{1}{2}}$ 7	
2b	3704.01	26990.1	5p $^4P^o_{2\frac{1}{2}}$ 8	
5	3693.53	27066.7	4d $^4P_{1\frac{1}{2}}$ – 5p $^4P^o_{1\frac{1}{2}}$	
00	3672.22	27223.8	5s $^2P_{\frac{1}{2}}$ – 5p $^4P^o_{1\frac{1}{2}}$	Br II line
0	3655.12	27351.1	5p $^4D^o_{2\frac{1}{2}}$ 4	
3	3612.33	27675.1	1 – 5p $^4D^o_{1\frac{1}{2}}$	
6	3551.08	28152.4	4d $^2P_{1\frac{1}{2}}$ – 5p $^4S^o_{1\frac{1}{2}}$	
00	3543.29	28214.3	4d $^4D_{2\frac{1}{2}}$ – 5p $^4D^o_{1\frac{1}{2}}$	
2	3531.54	28308.2	5p $^4P^o_{2\frac{1}{2}}$ – 9	
4	3528.86	28329.7	4d $^2P_{1\frac{1}{2}}$ – 5p $^2D^o_1$	?
2	3527.98	28336.8	5p $^4D^o_{2\frac{1}{2}}$ – 6	Br II line
3	3526.07	28352.1	5s $^2P_{1\frac{1}{2}}$ – 5p $^2D^o_{3\frac{1}{2}}$	
0	3512.97	28457.8	4d $^2F_2$ – 5p $^4D^o_{3\frac{1}{2}}$	
6	3506.47	28510.6	4d $^2D_{1\frac{1}{2}}$ – 5p $^4S^o_{1\frac{1}{2}}$	
2	3487.63	28664.6	4d $^4D_{1\frac{1}{2}}$ – 5p $^4D^o_{1\frac{1}{2}}$	
2	3433.96	29112.6	5p $^4P^o_{1\frac{1}{2}}$ – 8	
3vb	3425.29	29186.3	4d $^4D_{\frac{1}{2}}$ – 5p $^4D^o_{\frac{1}{2}}$	
1	3424.89	29189.7	4d $^4P_{1\frac{1}{2}}$ – 5p $^4P^o_{2\frac{1}{2}}$	
5	3417.61	29251.9	5p $^4D^o_{2\frac{1}{2}}$ – 7	
2h	3417.23	29255.1	4d ^4P – 5p $^4S^o_{1\frac{1}{2}}$	Br II line
2b	3416.39	29262.3	4d $^4P_{2\frac{1}{2}}$ – 5p $^4P^o_{1\frac{1}{2}}$	
3	3397.88	29421.7	5p $^4D^o_{1\frac{1}{2}}$ – 4	Br II line
2	3370.94	29656.8	4d $^4D_{3\frac{1}{2}}$ – 5p $^4D^o_{2\frac{1}{2}}$	
5	3349.75	29844.4	4d ^4D – 5p $^4D^o_{1\frac{1}{2}}$	
6	3321.08	30102.1	5s $^2P_{1\frac{1}{2}}$ – 5p $^2P^o_{1\frac{1}{2}}$	
5	3301.21	30283.2	4d $^4D_{2\frac{1}{2}}$ – 5p $^2D^o_{2\frac{1}{2}}$	
00b	3287.71	30407.6	5p $^4D^o_{1\frac{1}{2}}$ – 6	

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
2b	3285.21	30430.7	5p $^4P^o_{1\frac{1}{2}} - 9$	
1b	3277.15	30505.6	$1 - 5p\ \ ^4P^o_{\frac{1}{2}}$	
5	3270.07	30571.6	5p $^4P^o_{\frac{1}{2}} - 8$	
3	3252.74	30734.5	4d $^4D_{1\frac{1}{2}} - 5p\ \ ^4D^o_{2\frac{1}{2}}$	
5	3237.98	30874.6	5s $^2P_{1\frac{1}{2}} - 5p\ \ ^2D^o_{2\frac{1}{2}}$	
4	3214.59	31099.2	5s $^2P_{\frac{1}{2}} - 5p\ \ ^2S^o_{\frac{1}{2}}$	
4	3202.90	31212.7	4d $^2D_{1\frac{1}{2}} - 5p\ \ ^2D^o_{2\frac{1}{2}}$	
0	3194.85	31291.4	5s $^2P_{\frac{1}{2}} - 5p\ \ ^2D^o_{1\frac{1}{2}}$	
4	3185.21	31386.1	4d $^4P_{2\frac{1}{2}} - 5p\ \ ^4P^o_{2\frac{1}{2}}$	
5	3174.15	31495.4	4d $^4D_{1\frac{1}{2}} - 5p\ \ ^4P^o_{\frac{1}{2}}$	
4	3149.36	31743.3	4d $^4F_{3\frac{1}{2}} - 5p\ \ ^4D^o_{2\frac{1}{2}}$	
0bh	3134.75	31891.3	5p $^4P^o_{\frac{1}{2}} - 9$	
0bh	3133.04	31908 7	5p $^2P_{1\frac{1}{2}} - 5d\ \ ^4P$	
00h	3127.41	31966.1	$1 - 5p\ \ ^4P^o_{1\frac{1}{2}}$	
7	3117.29	32069.9	4d $^4D_{3\frac{1}{2}}\ \ 5p\ \ ^4D^o_{3\frac{1}{2}}$	
7	3091.94	32332.8	4d $^2F_{2\frac{1}{2}}\ \ 5p\ \ ^2D^o_{1\frac{1}{2}}$	
10	3074.42	32517.0	4d $^4F_{1\frac{1}{2}} - 5p\ \ ^4D^o_{3\frac{1}{2}}$	
1H	3059.60	32674.5	4d $^4D_{\frac{1}{2}} - 5p\ \ ^4P^o_{\frac{1}{2}}$	Br II line
2hb	3058.49	32686.4	5p $^4S^o_{1\frac{1}{2}} - 5d\ \ ^4P_{2\frac{1}{2}}$	
5	3057.57	32696.2	4d $^4D_{2\frac{1}{2}} - 5p\ \ ^4D^o_{3\frac{1}{2}}$	
2h	3042.08	32862.7	5p $^4S^o_{1\frac{1}{2}} - 11$	?
00	3040.04	32884.8	4d $^4P_{1\frac{1}{2}} - 5p\ \ ^2P^o_{1\frac{1}{2}}$	
7	3036.45	32923.6	5s $^2P_{\frac{1}{2}} - 5p\ \ ^2P^o_{\frac{1}{2}}$	
6	3033.63	32954.2	4d $^4D_{1\frac{1}{2}} - 5p\ \ ^4P^o_{1\frac{1}{2}}$	
4	3025.63	33041.4	5s $^2P_{\frac{1}{2}} - 5p\ \ ^2P^o_{1\frac{1}{2}}$	
0	3022.17	33079.2	5p $^4S^o_{1\frac{1}{2}} - 5d\ \ ^4P_{1\frac{1}{2}}$	
10	3020.76	33094.6	4d $^2F_{3\frac{1}{2}} - 5p\ \ ^2D^o_{2\frac{1}{2}}$	
8	2994.04	33390.0	4d $^4F_{1\frac{1}{2}} - 5p\ \ ^4D^o_{\frac{1}{2}}$	
7	2969.00	33671.6	4d $^4F_{2\frac{1}{2}} - 5p\ \ ^4D^o_{2\frac{1}{2}}$	
0hb	2952.88	33855.4	5p $^4P^o_{2\frac{1}{2}} - 5d\ \ ^4F_{2\frac{1}{2}}$	

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
3vbh	2946.26	33931.4	5p $^4P^o_{1}$ − 5d $^4F_{1}$	
6	2936.22	34047.5	4d $^4F_{1\frac{1}{2}}$ − 5p $^4D^o_{1}$	
2	2932.68	34088.6	1 − 5p $^4P^o_{2\frac{1}{2}}$	
8	2926.96	34155.2	4d $^4F_{3\frac{1}{2}}$ − 5p $^4D^o_{3\frac{1}{2}}$	
4	2901.89	34450.2	5p $^4P^o_{2\frac{1}{2}}$ − 5d $^4P_{2\frac{1}{2}}$	
4	2901.00	34460.8	5s $^4P_{2\frac{1}{2}}$ − 5p $^2D^o_{2\frac{1}{2}}$	
1h	2869.11	34843.8	5p $^4P^o_{2\frac{1}{2}}$ − 5d $^4P_{1\frac{1}{2}}$	
00b	2852.83	35042.6	5p $^4P^o_{3\frac{1}{2}}$ − 5d $^4D_{\frac{1}{2}}$	
2h	2849.91	35078.5	4d $^4D_{1\frac{1}{2}}$ − 5p $^4P^o_{2\frac{1}{2}}$	
2h	2843.79	35154.0	5p $^4S^o_{1\frac{1}{2}}$ − 13	
0h	2837.56	35231.2	$4p^4$ $^2P_{\frac{1}{2}}$ − 5p $^4D^o_{1\frac{1}{2}}$	
6	2804.16	35650.8	$4p^4$ $^2P_{1\frac{1}{2}}$ − 5p $^4D^o_{\frac{1}{2}}$	
3	2793.97	35780.8	5p $^4P^o_{\frac{1}{2}}$ − 5d $^4D_{1\frac{1}{2}}$	
6b	2785.28	35892.5	4d $^4F_{2\frac{1}{2}}$ − 5p $^4P^o_{1\frac{1}{2}}$	
3b	2784.21	35906.3	5p $^4S^o_{1\frac{1}{2}}$ − 14	
3	2781.09	35946.5	5p $^4D^o_{3\frac{1}{2}}$ − 5d $^4D_{2\frac{1}{2}}$	
8H	2772.62	36056.4	5p $^4P^o_{\frac{1}{2}}$ 10	
6	2770.50	36083.9	4d $^4F_{2\frac{1}{2}}$ − 5p $^4D^o_{3\frac{1}{2}}$	
2	2767 89	36118 0	4d $^4F_{1\frac{1}{2}}$ 5p $^4D^o_{2\frac{1}{2}}$	
?	2766.26	36139.2	5p $^4P^o_{1\frac{1}{2}}$ − 5d $^4D_{2\frac{1}{2}}$	
0h	2765.93	36143.6	5p $^4P^o_{2\frac{1}{2}}$ − 12	
3	2753.35	36308.7	$4p^4$ $^2P_{1\frac{1}{2}}$ − 5p $^4D^o_{1\frac{1}{2}}$	
4H	2752.06	36325.7	5p $^4P^o_{2\frac{1}{2}}$ 5d $^4D_{3\frac{1}{2}}$	
3H	2747.18	36390.2	4d $^4D_{2\frac{1}{2}}$ − 5p $^4S^o_{1\frac{1}{2}}$	
2H	2742.36	36454.2	5p $^2P^o_{\frac{1}{2}}$ 17	
7H	2735.83	36541.2	5p $^4D^o_{2\frac{1}{2}}$ − 5d $^4D_{1\frac{1}{2}}$	
00	2733.43	36573.3	5p $^4P^o_{1\frac{1}{2}}$ − 5d $^4P_{2\frac{1}{2}}$	
			4d $^4D_{2\frac{1}{2}}$ − 5p $^2D^o_{1\frac{1}{2}}$	
1h	2731.35	36601.1	5s $^4P_{\frac{1}{2}}$ − 5p $^4S^o_{1\frac{1}{2}}$	
1	2720.15	36751.8	5p $^4P^o_{1\frac{1}{2}}$ − 11	

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
3h	2719.39	36762.1	$5p\ ^4D^o_{1\frac{1}{2}} - 5d\ ^4F_{1\frac{1}{2}}$	
00	2715.37	36816.5	$5p\ ^4D^o_{2\frac{1}{2}} - 10$	
1	2710.83	36878.2	$4d\ ^4F_{1\frac{1}{2}} - 5p\ ^4P^o_{\frac{1}{2}}$	
4	2704.28	36967.5	$5p\ ^4P^o_{1\frac{1}{2}} - 5d\ ^4P_{1\frac{1}{2}}$	
7h	2671.53	37420.6	$5p\ ^4D^o_{\frac{1}{2}} - 5d\ ^4F_{1\frac{1}{2}}$	
2	2649.82	37727.2	$5p\ P^o_{1\frac{1}{2}} - 5d\ ^4P_{\frac{1}{2}}$	
0	2645.19	37793.2	$5p\ ^4P^o_{1\frac{1}{2}} - 6s\ ^4P_{2\frac{1}{2}}$	
7h	2639.60	37873.3	$5p\ ^4D^o_{1\frac{1}{2}} - 5d\ ^4D_{\frac{1}{2}}$	
4	2632.88	37969.9	$5p\ ^2D^o_{2\frac{1}{2}} - 21$	
7h	2629.23	38022.6	$4d\ ^4D_{\frac{1}{2}} - 5p\ ^4S^o_{1\frac{1}{2}}$	
10H	2626.52	38061.9	$4p^4\ ^2P_{\frac{1}{2}} - 5p\ ^4P^o_{\frac{1}{2}}$	
3	2617.08	38199.9	$5p\ ^4D^o_{2\frac{1}{2}} - 5d\ ^4F_{2\frac{1}{2}}$	
7h	2616.26	38211.1	$5p\ ^4P^o_{\frac{1}{2}} - 11$	
10H	2613.13	38256.9	$5p\ ^4D^o_{3\frac{1}{2}} - 5d\ ^4D_{3\frac{1}{2}}$	
7H	2608.15	38329.9	$5p\ ^4S^o_{1\frac{1}{2}} - 18$	
9H	2606.20	38358.6	$5p\ ^4D^o_{2\frac{1}{2}} - 5d\ ^4D_{2\frac{1}{2}}$	
3h	2601.58	38426.7	$5p\ ^4P^o_{\frac{1}{2}} - 5d\ ^4P_{1\frac{1}{2}}$	
1H	2597.69	38484.3	$5p\ ^2P^o_{1\frac{1}{2}} - 20$	
8h	2595.98	38509.7	$5p\ ^4D^o_{3\frac{1}{2}} - 5d\ ^4F_{3\frac{1}{2}}$	
6H	2594.48	38531.9	$5p\ ^4D^o_{\frac{1}{2}} - 5d\ ^4D_{\frac{1}{2}}$	
10	2589.14	38611.3	$5p\ ^4D^o_{1\frac{1}{2}} - 5d\ ^4D_{1\frac{1}{2}}$	
8h	2584.99	38673.3	$5p\ ^4P^o_{2\frac{1}{2}} - 15$	
6H	2573.17	38850.9	$5p\ ^4D^o_{3\frac{1}{2}} - 13$	
7H	2570.83	38886.3	$5p\ ^4D^o_{1\frac{1}{2}} - 10$	
2h	2565.22	38971.3	$5p\ ^4D^o_{2\frac{1}{2}} - 11$	
1	2554.21	39139.3	$4p^4\ ^2P_{1\frac{1}{2}} - 5p\ ^4P^o_{\frac{1}{2}}$	
7h	2551.09	39187.1	$5p\ ^4P^o_{\frac{1}{2}} - 5d\ ^4P_{\frac{1}{2}}$	
			$5p\ ^4D^o_{2\frac{1}{2}} - 5d\ ^4P_{1\frac{1}{2}}$	
7	2529.49	39251.8	$4p^4\ ^2P_{\frac{1}{2}} - 5p\ ^4P^o_{1\frac{1}{2}}$	
1h	2527.92	39546.3	$5p\ ^4D^o_{\frac{1}{2}} - 10$	?

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
1h	2524.43	39601.0	5p $^4D^o_{3\frac{1}{2}}$ 14	
00	2513.08	39779.8	4d $^4F_{2\frac{1}{2}}$ – 5p $^4S^o_{1\frac{1}{2}}$	
5	2497.43	40029.1	5p $^4P^o_{2\frac{1}{2}}$ – 17	
6	2482.60	40268.2	5p $^4D^o_{1\frac{1}{2}}$ – 5d $^4F_{2\frac{1}{2}}$	
3h	2469.17	40487.2	5p $^4D_{2\frac{1}{2}}{}^o$ – 12	
6	2462.39	40598.7	$4p^4$ $^2P_{1\frac{1}{2}}$ – 5P $^4P^o_{1\frac{1}{2}}$	
1bh	2450.44	40796.6	5p $^4P^o_{1\frac{1}{2}}$ – 15	
3h	2443.01	40920 7	5p $^4D^o_{2\frac{1}{2}}$ – 5d $^4F_{3\frac{1}{2}}$	
4h	2435.76	41042 5	5p $^4D^o_{1\frac{1}{2}}$ – 11	
0h	2423.08	41257.3	5p $^4D^o_{1\frac{1}{2}}$ – 5d $^4P_{1\frac{1}{2}}$	
1h	2422 71	41263.6	5p $^4D_{2\frac{1}{2}}{}^o$ – 13	
4b	2397.31	41700.7	5p $^4D^o_{\frac{1}{2}}$ – 11	
1	2396.07	41722.3	5p $^4P^o_{1\frac{1}{2}}$ – 16	
3	2379.48	42013.2	5p $^4D^o_{2\frac{1}{2}}$ 14	
4	2378.73	42026.4	5p $^4D^o_{3\frac{1}{2}}$ 18	
00	2375.50	42083.5	5p $^4D^o_{1\frac{1}{2}}$ - 6s $^4P_{2\frac{1}{2}}$	
3	2371.63	42152 2	5p $^4P^o_{1\frac{1}{2}}$ – 17	
0	2365.79	42256.3	5p $^4P^o_{\frac{1}{2}}$ – 15	
0	2349.06	42557.2	5p $^4D^o_{1\frac{1}{2}}$ - 12	
4	2339.95	42722.8	$4p^4$ $^2P_{1\frac{1}{2}}$ – 5p $^4P^o_{2\frac{1}{2}}$	
2	2326.41	42971.5	5p $^4S^o_{1\frac{1}{2}}$ - 22	
0	2323.96	43016.8	5p $^4D^o_{2\frac{1}{2}}$ – 15	
6	2313.29	43215.2	5p $^4D^o_{\frac{1}{2}}$ 12	
0	2299.66	43471.3	5p $^4D^o_{3\frac{1}{2}}$ – 19	
8vbh	2293.44	43589.2	$4p^4$ $^2P_{\frac{1}{2}}$ – 5p $^2D^o_{1\frac{1}{2}}$	
4	2292.27	43611.4	5p $^4P^o_{\frac{1}{2}}$ – 17	
1bh	2289.49	43664.4	5p $^4P^o_{1\frac{1}{2}}$ – 19	
0	2274.94	43943.6	5p $^4D^o_{2\frac{1}{2}}$ - 16	
4	2270.02	44038.8	4d $^4F_{1\frac{1}{2}}$ – 5p $^2P^o_{\frac{1}{2}}$	
1	2256.52	44302.3	5p $^4P^o_{1\frac{1}{2}}$ – 20	

TABLE II (*contd.*)

Intensity	λ(air)	ν(vac)	Classification	Remarks
0	2249.63	44437.9	$5p\ {}^4D^o_{2\frac{1}{2}} - 18$	
1	2243.43	44560.7	$5p\ {}^4P^o_{1\frac{1}{2}} - 21$	
00	2234.59	44737.0	$5p\ {}^4P^o_{2\frac{1}{2}} - 22$	
00	2210.63	45221.8	$4p^4\ {}^2P_{\frac{1}{2}} - 5p\ {}^2P^o_{\frac{1}{2}}$	
2	2184.55	45761.7	$5p\ {}^4P^o_{\frac{1}{2}} - 20$	
3	2178.74	45883.7	$5p\ {}^4D^o_{2\frac{1}{2}} - 19$	
2	2172.62	46012.9	$5p\ {}^4D^o_{1\frac{1}{2}} - 16$	
0	2172.30	46019.7	$5p\ {}^4P^o_{\frac{1}{2}} - 21$	
?	2153.68	46418.2	$4p^4\ {}^2P_{1\frac{1}{2}} - 5p\ {}^2P^o_{1\frac{1}{2}}$	
?	2152.52	46442.5	$5p\ {}^4D^o_{1\frac{1}{2}} - 17$	
4	2133.35	46859.8	$5p\ {}^4P^o_{1\frac{1}{2}} - 22$	
3	2118.51 (vac)	47188.0	$4p^4\ {}^2P_{1\frac{1}{2}} - 5p\ {}^2D^o_{2\frac{1}{2}}$	
2	1475.1	67790	$4p^4\ {}^4P_{\frac{1}{2}} - 5p\ {}^4D^o_{\frac{1}{2}}$	
00	1434.7	69703	$4p^4\ {}^4P_{1\frac{1}{2}} - 5p\ {}^4D^o_{1\frac{1}{2}}$	
5	1402.9	71283	$4p^4\ {}^4P_{\frac{1}{2}} - 5p\ {}^4P^o_{\frac{1}{2}}$	
1	1393.0	71789	$4p^4\ {}^4P_{1\frac{1}{2}} - 5p\ {}^4D^o_{2\frac{1}{2}}$	
2	1383.1	72303	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4D^o_{1\frac{1}{2}}$	
2	1351.4	73996	$4p^4\ {}^4P_{1\frac{1}{2}} - 5p\ {}^4P^o_{1\frac{1}{2}}$	
1	1344.6	74374	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4D^o_{2\frac{1}{2}}$	
5	1313.5	76135	$4p^4\ {}^4P_{1\frac{1}{2}} - 5p\ {}^4P^o_{2\frac{1}{2}}$	
1	1305.6	76591	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4P^o_{1\frac{1}{2}}$	
0	1304.9	76632	$4p^4\ {}^4P_{\frac{1}{2}} - 5p\ {}^4S^o_{1\frac{1}{2}}$	Oxygen I
0	1303.7	76708	$4p^3\ {}^2P^o_{1\frac{1}{2}} - 4p^4\ {}^4P_{\frac{1}{2}}$	
3	1302.2	76794	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4D^o_{3\frac{1}{2}}$	Oxygen I
1	1297.5	77074	$4p^3\ {}^2P^o_{\frac{1}{2}} - 4p^4\ {}^4P_{1\frac{1}{2}}$	
0	1283.7	77903	$4p^4\ {}^4P_{1\frac{1}{2}} - 5p\ {}^4S^o_{1\frac{1}{2}}$	
00	1272.8	78567	$4p^4\ {}^4P_{\frac{1}{2}} - 5p\ {}^2P^o_{1\frac{1}{2}}$	
2	1270.3	78724	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4P^o_{2\frac{1}{2}}$	
3	1242.2	80500	$4p^4\ {}^4P_{2\frac{1}{2}} - 5p\ {}^4S^o_{1\frac{1}{2}}$	
9	984.9	101532	$4p^3\ {}^4S^o_{1\frac{1}{2}} - 4p^4\ {}^4P_{2\frac{1}{2}}$	

TABLE II (*contd.*)

Intensity	λ(vac)	ν(vac)	Classification	Remarks
8	960.4	104129	$4p^3\ {}^4S^o_{1\frac{1}{2}} - 4p^4\ {}^4P_{1\frac{1}{2}}$	
7	949.0	105380	$4p^3\ {}^4S^o_{1\frac{1}{2}} - 4p^4\ {}^4P_{\frac{1}{2}}$	
2	807.4	123856	$4p^3\ {}^2P^o_{\frac{1}{2}} - 5s\ {}^2P_{\frac{1}{2}}$	
0	805.7	124116	$4p^3\ {}^2P^o_{1\frac{1}{2}} - 4d\ {}^4P_{\frac{1}{2}}$	
5	798.8	125186	$4p^3\ {}^2P^o_{1\frac{1}{2}} - 5s\ {}^2P_{1\frac{1}{2}}$	
0	794.1	125926	$4p^3\ {}^2P^o_{\frac{1}{2}} - 3$	
00	788.7	126794	$4p^3\ {}^2P^o_{\frac{1}{2}} - 5s\ {}^2P_{1\frac{1}{2}}$	Br II
00	773.2	129339	$4p^3\ {}^2D^o_{2\frac{1}{2}}\ \ 4d\ {}^4D_{2\frac{1}{2}}$	
3	768.8	130075	$4p^3\ {}^2D^o_{1\frac{1}{2}} - 4d\ {}^4D_{1\frac{1}{2}}$	
1	761.3	131361	$4p^3\ {}^2D^o_{2\frac{1}{2}}\ \ 5s\ {}^4P_{1\frac{1}{2}}$	
2	759.9	131596	$4p^3\ {}^2P^o_{1\frac{1}{2}}\ \ 5s'\ {}^2D_{2\frac{1}{2}}$	
3	754.5	132535	$4p^3\ {}^2P^o_{1\frac{1}{2}}\ \ 5s'\ {}^2D_{1\frac{1}{2}}$	
1	746.6	133948	$4p^3\ {}^2D^o_{2\frac{1}{2}} - 5s\ {}^4P_{2\frac{1}{2}}$	
2	745.5	134142	$4p^3\ {}^2P^o_{\frac{1}{2}}\ \ 5s'\ {}^2D_{1\frac{1}{2}}$	
2	740.8	134984	$4p^3\ {}^2P^o_{1\frac{1}{2}}\ \ 4p^4\ {}^2D_{1\frac{1}{2}}$	
00	739.9	135150	$4p^3\ {}^2D^o_{1\frac{1}{2}}\ \ 5s\ {}^4P_{2\frac{1}{2}}$	
6	736.4	135801	$4p^3\ {}^2D^o_{1\frac{1}{2}} - 5s\ {}^2P_{2\frac{1}{2}}$	
00	731.7	136674	$4p^3\ {}^2D^o_{2\frac{1}{2}}\ \ 3$	
6	727.0	137546	$4p^3\ {}^2D^o_{2\frac{1}{2}} - 5s\ {}^2P_{1\frac{1}{2}}$	
00	720.8	138742	$4p^3\ {}^2D^o_{1\frac{1}{2}} - 5s\ {}^2P_{1\frac{1}{2}}$	
8	690.2	144890	$4p^3\ {}^2D^o_{2\frac{1}{2}}\ \ 5s'\ {}^2D_{1\frac{1}{2}}$	
3	688.9	145153	$4p^3\ {}^2D^o_{1\frac{1}{2}} - 5s'\ {}^2D_{2\frac{1}{2}}$	
1	678.7	147351	$4p^3\ {}^2D^o_{2\frac{1}{2}} - 4p^4\ {}^2D_{1\frac{1}{2}}$	
6	677.8	147545	$4p^3\ {}^2D^o_{2\frac{1}{2}} - 4p^4\ {}^2D_{2\frac{1}{2}}$	
0	672.3	148741	$4p^3\ {}^2D^o_{1\frac{1}{2}}\ \ 4p^4\ {}^2D_{2\frac{1}{2}}$	
6	620.4	161199	$4p^3\ {}^4S^o_{1\frac{1}{2}}\ \ 5s'\ {}^2D_{1\frac{1}{2}}$	
9	611.1	163650	$4p^3\ {}^4S^o_{1\frac{1}{2}} - 4p^4\ {}^2D_{1\frac{1}{2}}$	

Attempts to locate the 6p levels with the help of the 6s ${}^4P$ intervals have led to the identification of the two levels 23^o and 24^o.

Using the Rydberg formula the absolute value of 5s ${}^4P_{2\frac{1}{2}}$ is obtained by Rao and Krishna Murty as 139269.0 cm^{-1} from the two members of the ns ${}^4P$ series.

This gives the limit 289529 cm^{-1} corresponding to a third ionisation potential of 35.89 volts. The calculation is verified and found correct. This is, therefore, adopted as the limit.

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